

**LISTING OF CLAIMS:**

1. *(Currently Amended)* An apparatus for sending a heartbeat signal in a cluster computing system, the apparatus comprising:

a first host group; and

a first storage system comprising a first heartbeat storage volume and a first data storage volume, the first storage system being associated with the first host group, the first host group coupled via a network to a second host group, the first storage system coupled via a remote link separate from the network to a second storage system comprising a second heartbeat storage volume and a second data storage volume, the second storage system being associated with the second host group, the first host group configured to selectively send a heartbeat signal to the second host group by use of the remote link by sending a memory command to the first heartbeat storage volume of the first storage system which is mirrored via the remote link using a remote copy mechanism to the second heartbeat storage volume of the second storage system, wherein the second host group is configured to use the received heartbeat signal to determine whether a failover should be performed; and wherein:

the first heartbeat storage volume and the second heartbeat storage volume form a remote mirror being in an enabled mode;

the first heartbeat storage volume is registered to a device address entry;

the first host group operable to send an activation message to the second host group; and

the second heartbeat volume is registered to the device address entry.

2. *(Currently Amended)* A method of sending a heartbeat signal in a cluster computing system, the method comprising:

a. generating a heartbeat signal from a first host group in a production site, the first host group being associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;

b. installing remote mirrors in the cluster computing system, including:  
registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;  
registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and  
from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal from the first host group to a second host group by use of thea remote link-coupled mirror formed by the first heartbeat storage volume and the second heartbeat storage volume between the first storage system and a second storage system comprising a second heartbeat storage volume and a second data storage volume, the second storage system being associated with the second host group, the heartbeat signal being sent from the first heartbeat storage volume of the first storage system via the remote link to the second

heartbeat storage volume of the second storage system using a remote copy mechanism, wherein the second host group uses the received heartbeat signal to determine whether a failover should be performed.

3. *(Currently Amended)* An electronically-readable medium storing a program for permitting a computer to perform method of sending a heartbeat signal in a cluster computing system, the method comprising:

a. generating a heartbeat signal from a first host group in a production site, the first host group being associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;

b. installing remote mirrors in the cluster computing system, including:  
registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;

registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and  
from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal from the first host group to a second host group by use of the remote link coupled mirror formed by the first heartbeat storage volume and the second heartbeat storage volume, between the first storage system and a second storage system comprising a second heartbeat storage volume and a second data storage volume, the

~~second storage system being associated with the second host group, the heartbeat signal being sent from the first heartbeat storage volume of the first storage system via the remote link to the second heartbeat storage volume of the second storage system using a remote copy mechanism, wherein the second host group uses the received heartbeat signal to determine whether a failover should be performed.~~

4. *(Currently Amended)* A program code embedded on a computer readable medium carrier wave for causing a computer to perform a method of sending a heartbeat signal in a cluster computing system, the method comprising:

a. generating a heartbeat signal from a first host group in a production site, the first host group being associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;

b. installing remote mirrors in the cluster computing system, including:

registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;

registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal from the first host group to a second host group by use of thea remote mirror formed by the first heartbeat storage volume and the second

heartbeat storage volume, link coupled between the first storage system and a second storage system comprising a second heartbeat storage volume and a second data storage volume, the second storage system being associated with the second host group, the heartbeat signal being sent from the first heartbeat storage volume of the first storage system via the remote link to the second heartbeat storage volume of the second storage system using a remote copy mechanism, wherein the second host group uses the received heartbeat signal to determine whether a failover should be performed.

5.-9. (*Cancelled*) *Currently Amended*) An apparatus for receiving a heartbeat signal in a cluster computing system, the apparatus comprising:

a remote host group; and

a remote storage system comprising a remote heartbeat storage volume and a remote data storage volume, the remote storage system being associated with the remote host group, the remote host group configured to selectively receive a heartbeat signal by use of a remote link coupled to the remote storage system, the heartbeat signal being received by the remote heartbeat storage volume of the remote storage system via the remote link using a remote copy mechanism, wherein the remote host group is configured to use the received heartbeat signal to determine whether a failover should be performed.

6. *Currently Amended*) A method of receiving a heartbeat signal in a cluster computing system, the method comprising:

selectively receiving a heartbeat signal in a remote host group by use of a remote link coupled with a storage system comprising a heartbeat storage volume and a data storage volume, the storage system being associated with the remote host group, the heartbeat signal being

received via the remote link at the heartbeat storage volume of the storage system using a remote copy mechanism, wherein the remote host group uses the received heartbeat signal to determine whether a failover should be performed.

7. *(Currently Amended)* An electronically readable medium storing a program for permitting a computer to perform a method of receiving a heartbeat signal in a cluster computing system, the method comprising:

selectively receiving a heartbeat signal in a remote host group by use of a remote link coupled with a storage system comprising a heartbeat storage volume and a data storage volume, the storage system being associated with the remote host group, the heartbeat signal being received by the heartbeat storage volume of the storage system via the remote link using a remote copy mechanism, wherein the remote host group uses the received heartbeat signal to determine whether a failover should be performed.

8. *(Currently Amended)* A program code embedded on a carrier wave for causing a computer to perform a method of receiving a heartbeat signal in a cluster computing system, the method comprising:

selectively receiving a heartbeat signal in a remote host group by use of a remote link coupled with a storage system comprising a heartbeat storage volume and a data storage volume, the storage system being associated with the remote host group, the heartbeat signal being received by the heartbeat storage volume of the storage system via the remote link using a remote copy mechanism, wherein the remote host group uses the received heartbeat signal to determine whether a failover should be performed.

9. *(Currently Amended)* A cluster computing system, comprising:

a production host group;

a first storage system comprising a first heartbeat storage volume and a first data storage volume, the first storage system being associated with the production host group;

a standby host group coupled to the production host group by a network;

a second storage system comprising a second heartbeat storage volume and a second data storage volume, the second storage system being associated with the standby host group; and

a remote mirror coupled between the production host group and the standby host group, the remote mirror being separate from the network;

the production host group configured to selectively send a heartbeat signal to the standby host group by use of the remote mirror, the heartbeat signal being sent from [[a]] the first heartbeat storage volume of the first storage system associated with the production host group via the remote mirror to [[a]] the second heartbeat storage volume of the second storage system associated with the standby host group using a remote copy mechanism, wherein the standby host group is operable to use the received heartbeat signal to determine whether a failover should be performed.

10. *(Currently Amended)* A method of checking for failure in a cluster computing system, the method comprising:

- a. generating a heartbeat signal from a first host group in a production site associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;
- b. installing remote mirrors in the cluster computing system, including:

registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;

registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal from the first host group to a second to host group associated with a second storage system comprising a second heartbeat storage volume and a second data storage volume by use of thea remote mirror formed by the first heartbeat storage volume and the second heartbeat storage volume, mirror coupled between the host groups, the heartbeat signal being sent from-[[a]] the first heartbeat storage volume of the first storage system associated with the first host group via the remote mirrorremote link to-[[a]] the second heartbeat storage volume of the second storage system associated with the second host group using a remote copy mechanism, wherein the second host group uses the received heartbeat signal to determine whether a failure has occurred.

11. *(Currently Amended)* A cluster computing system, comprising:

a production host group associated with a production storage system comprising a production site heartbeat storage volume (heartbeat PVOL) and a production site data storage volume;

a standby host group coupled to the production host group by a network and associated with a standby storage system comprising a standby site heartbeat storage volume (heartbeat SVOL) and a standby site data storage volume; and

a remote mirror coupled between the production host group and the standby host group, the remote mirror including the heartbeat PVOL and the heartbeat SVOL coupled by a remote link to the heartbeat PVOL, the remote mirror being separate from the network;

the production host group configured to selectively send a heartbeat signal to the standby host group by use of the remote link using a remote copy mechanism, wherein the standby host group uses the received heartbeat signal to determine whether a failover should be performed and wherein:

the remote mirror being in an enabled mode;

the heartbeat PVOL is registered to a device address entry;

the production host group is operable to send an activation message to the standby host group; and

the heartbeat SVOL is registered to the device address entry.

12. (*Original*) The cluster computing system of claim 11 wherein the production host group comprises a first heartbeat check module configured to generate the heartbeat signal.

13. (*Original*) The cluster computing system of claim 11 wherein the standby host group comprises a second heartbeat check module configured to receive the heartbeat signal.

14. (*Original*) The cluster computing system of claim 11 wherein the standby host group manages operations of the cluster computing system if an invalid heartbeat signal is received by the standby host group from the production host group.

15. (*Original*) The cluster computing system of claim 11 wherein the heartbeat message comprises: a serial number assigned to the heartbeat message, a time indicator indicating a time of the generation of the heartbeat message, and an identifier identifying a sender of the heartbeat message.

16. (*Previously Presented*) The cluster computing system of claim 11 further comprising:

a second remote mirror coupled between the production host group and the standby host group, the second remote mirror including a second remote link for transmitting a heartbeat signal;

the standby host group configured to selectively send a heartbeat signal to the production host group by use of the second remote link.

17. (*Currently Amended*) A method of checking for failure in a cluster computing system, the method comprising:

a. generating a heartbeat signal from a production host group in a production site associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;

b. installing remote mirrors in the cluster computing system, including:

registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;

registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal to a standby host group in the standby site associated with a second storage system comprising a second heartbeat storage volume and a second data storage volume from the production host group in the production site by use of the remote mirror formed by the first heartbeat storage volume and the second heartbeat storage volume link using a remote copy mechanism between the first heartbeat storage volume and the second heartbeat storage volume;

d. determining, by the standby host group, that a failure has occurred, if an invalid heartbeat signal is received by the standby host group from the production host group; and

e. enabling the standby host group to manage operations of the cluster computing system if the failure has occurred.

18. *(Previously Presented)* The method of claim 17 further comprising:

selectively sending a heartbeat signal to the production host group from the standby host group by use of a second remote link.

19. *(Cancelled)*

20. *(Original)* The method of claim 17 further comprising:  
de-installing remote mirrors in the cluster computing system, including:  
from a production site, changing a remote mirror into a disabled mode;  
sending a de-activation message from the first production site to a standby site; and  
from the standby site, changing the remote mirror into a disabled mode to de-install the  
remote mirror.

21. *(Original)* The method of claim 17 wherein the selectively sending step  
comprises:

determining if a network between the production site host and the standby site host is  
enabled;  
if the network is enabled, sending a heartbeat message along the network from the  
production site host to the standby site host;  
determining if a remote mirror between the production site host and the standby site host  
is enabled; and  
if the remote mirror is enabled, sending a heartbeat message along the remote mirror  
from the production site host to the standby site host.

22. *(Original)* The method of claim 17 further comprising:  
receiving a heartbeat message from the production site host to the standby site host in the  
cluster computing system, including:  
determining if a network between the production site host and the standby site host is  
enabled;

if the network is enabled, checking for a heartbeat message along the network from the production site host to the standby site host;

determining if a remote mirror between the production site host and the standby site host is enabled;

if the remote mirror is enabled, checking for a heartbeat message along the remote mirror from the production site host to the standby site host; and if an invalid heartbeat is received along the network and along the remote mirror, enabling the standby host to manage operations of the cluster computing system.

23-24. (*Canceled*)